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ABSTRACT

Concern has been expressed in recent years about the accuracy of medication administered by nurses in Papua New Guinean hospitals. Attention has been focused on the calculation of the drug dosages. This paper discusses the processes involved in the administration of medication, and reports on a study to evaluate the competence of student nurses at both theoretical and practical aspects of drug administration. The study aimed: to examine the abilities of student nurses on calculating drug dosages by a paper/pencil test; to examine the abilities of student nurses in the practical administration of drug dosages; to determine the extent of the relationship between the two tests; and to investigate the extent and type of student errors in the tests. Results indicate that these students are experiencing little difficulty with the calculation of the dosages on paper, but there are additional errors apparent in practice. Therefore, it is argued that drug administration must be seen as an entire process, and should be taught and tested as such. This supports the argument that vocational mathematical skills must be taught in the context in which they are used if the students are to be able to apply their skills successfully in the real situation. (Author/JN)

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PRACTICAL ASPECTS OF DRUG CALCULATIONS

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MATHEMATICS EDUCATION CENTRE

REPORT 24

M.E.C. REPORT NO. 24

PRACTICAL ASPECTS OF DRUG CALCULATIONS

PETER SULLIVAN

M.E.C.
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PRACTICAL ASPECTS OF DRUG CALCULATIONS

PETER SULLIVAN

AUGUST 1982

ABSTRACT: Concern has been expressed in recent years about the accuracy of of the medication administered by nurses in Papua New Guinean hospitals. Attention has been focussed on the calculation of the drug dosages. This paper discusses the processes involved in the administration of medication, and reports on a study to evaluate the competence of student nurses at both theoretical and practical aspects of drug administration. The students are experiencing little difficulty with the calculation of the dosages on paper, but there are additional errors apparent in practice. It is argued that drug administration must be seen as an entire process, and should be taught and tested as such. This supports the argument that vocational mathematical skills must be taught in the context in which they are used if the students are to be able to apply their skills successfully in the real situation.

1. BACKGROUND

1.1 THE ACTION OF DRUGS

Drugs can be used for prevention, treatment and diagnosis (Wong and Jones, 1980). They can act in one particular part of the body or through an entire system, and are generally transported by the blood. They can be administered directly into the blood, into the intestinal tract through the mouth, into the skeletal muscles, just under the skin or on top of the skin. (Goldstein et al., 1969). The size of the dose is dependent on the disease, the action of the drug, the body size of the patient, the surface area of skin, on age in the case of children (Perlstein et al., 1962), and on both the gestational and post-natal age of babies (Bleyer and Koup, 1962).

Once administered, the drug must reach the site or sites at which action is wanted in high enough quantities and for long enough time for the desired effect to be achieved (Wong and Jones, 1980). The rate at which the drug dissipates, either by passing through the kidneys, being broken down by the body or accumulating in tissues must be considered (Goldstein et al., 1969), as must the patient's tolerance, the toxicity of the drug, the known side-effects, the availability and the freshness of the drug.

1.2 PRESCRIBING DRUGS

The staffing of hospitals in Papua New Guinea is such that the doctors usually examine the patients only once in each day.

After the examination, the doctor will write his observations, comments, diagnosis and prescriptions of medication on each patient's record. This becomes the permanent record of the symptoms and treatment. Any drugs which are prescribed are transferred from this record onto a specially prepared chart which will indicate the drug, method of administration, dosage and times of administration. Most hospitals have a predetermined schedule for the dispensing of drugs to the patients. The nurses will consult the drug record, collect the medication from the ward supplies, or the pharmacy if necessary, calculate the dosage, administer the drug, then sign the record to indicate that the drug has been given.

Drugs can be prescribed in many forms. The most common forms are tablets and suspensions which are given orally, and injections. The tablets are labelled as containing a certain mass of active ingredient; for example, there is 50 mg of active drug in 1 tablet of INAH. The doctor can prescribe INAH[1] in tablets or in milligram (mg) of active drug. Suspensions are designated as containing a certain mass of active ingredient in a given amount of solution; for example, Chloramphenicol[2] suspenson contains 125mg of active drug in 5 millilitres (mL) of solution. The doctor can therefore prescribe a particular dose by mass of active ingredient, mg, or by the amount of solution, mL.

Drugs for injections are available in 2 forms, ampoules and vials. Ampoules contain a certain amount of active drug in a given amount of solution; for example, Pethedine[3] is supplied in

---

(1) INAH, isoniazid, is used to treat tuberculous

(2) Chloramphenicol is an antibiotic

(3) Pethedine is an analgesic

an ampoule containing 100mg of active drug in 2mL of solution. The doctor can prescribe by mass, mg, or amount of solution, mL. In vials the drug comes in powder form to which sterile water is added. This then becomes a fixed amount of solution containing a certain quantity of active ingredient which can be specified either by mass or in units. For example, 1.5mL of sterile water is added to a vial of Streptomycin[4] to give 1g of active drug in 2mL of solution, and 2 mL of sterile water is added to a vial of Crystapen[5] to give 1 000 000 units in 2mL of solution. The prescription can be written as the mass or the number of units, as the case may be, or it can be written in mL of solution.

The most direct method of prescription is for the drug to be ordered in its active form; that is, in terms of the mass of the active ingredient. This means that the nurse is required to convert this to the form in which the drug will be administered, usually tablets or mL of solution.

1.3 MEDICATION ERRORS

The drug delivery process requires many decisions by both doctors and nurses. The diagnosis must be correct, the correct drug selected, the correct route of administration and dosage chosen. The dosage must be modified according to correctly measured body surface area, weight and age. The rate and frequency of administration must be chosen and then this must be accurately conveyed to the nurse. The nurse must interpret the order correctly, calculate the necessary dosage in the form available, locate the correct drug, prepare the correct amount.

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(4) Streptomycin is an antibiotic

(5) Crystapen, crystalline penicillin, is an antibiotic.

locate the correct patient, and administer the drug at the indicated rate and by the indicated route (Bleyer and Koup, 1979). There is potential for error at each step in the above process.

Barker and McConnell (1962) categorise nursing errors as ommissions, incorrect dosages, the giving of an extra dose or an unordered drug, use of the wrong form of a drug, or the giving of the drug at the wrong time or by the wrong route. Perlstein et al. (1979) attribute the major sources of error to inappropriate prescription, illegible prescription, and misinterpretation or miscalculation by the nurse. Other errors which can occur are the use of drugs which are past their expiry date for effective action, and the giving of the drug to an incorrect patient. In addition, the whole process can be disturbed by the refusal of the patient to take the drug for a variety of cultural reasons.

The situation is further complicated because patients have adverse reactions to drugs or combinations of drugs (Mabadeje and Ilawole, 1979), inaccurate records are maintained (Monson and Bond, 1978) and there can be errors in the preparation of the stock drug (McCormack et al., 1978).

The steps which are the responsibility of the nurses are the primary concern here, but all of the above factors will influence the product. For example, if the prescription made by the doctor is difficult to read, and they very often are, then a nurse who experiences difficulty with the dosage calculations, or who is uncertain about forms and usages will have increased chances of making an error.

1.4 DRUG CALCULATIONS

The calculation of the dose to be given is only one step in the drug delivery process. It is considered to be the most likely source of error (Perlstein et al.,1979), and nurses, nursing administrators and doctors have all expressed concern at the difficulties which nurses are experiencing with the calculation of dosages. It is this step which the present report investigated.

An example of the type of calculation which is necessary is as follows:

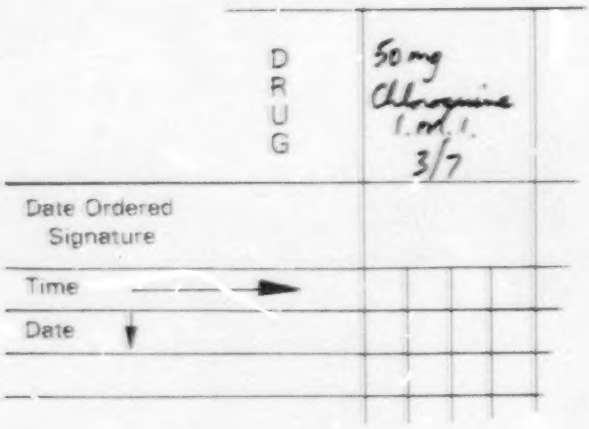

Figure 1. Order form used in hospitals for prescribing drugs.

Figure 2. The ampoule in which this drug is available.

The available concentration of drug is 80mg in 2mL of solution (figure 2). The prescribed dose is 50mg (figure 1). The nurses' problem is to calculate the required amount of solution which can be found by proportional reasoning.

In the schools of nursing, the generally adopted strategy is to use the rule

$$\text{Dose} = \frac{\text{What you WANT}}{\text{What you HAVE}} \times \text{AMOUNT you have}$$

In this rule

"What you WANT" means the prescribed drug
"What you HAVE" means the quantity of drug available
"AMOUNT you have" means the amount containing the active drug

In this case

"WANT" is 50 mg
"HAVE" is 80 mg
"AMOUNT" is 2 ml

$$\text{so} \quad \text{DOSE} = \frac{\text{WANT}}{\text{HAVE}} \times \text{AMOUNT}$$

$$= \frac{50 \text{ mg}}{80 \text{ mg}} \times 2 \text{ ml}$$

$$= 1.25 \text{ ml}$$

If the units of "WANT" and "HAVE" are not the same, then one must be converted. "WANT" can also be given in units instead of mass, but the calculation process in each case, is indentical to the example above.

The educational value or otherwise of using the above rule will not be debated here. This report seeks to examine the situation as it exists in the hospitals and schools of nursing. The choice of an appropriate teaching strategy in these and similar cases will be discussed in a future report.

Another type of calculation is used when the doctor

prescribes 200mg of INAH, for example, and the drug is available in 50mg tablets. The nurses experience no difficulty with these calculations, and so our attention is directed to the earlier example.

A study in the U.S.A. which sought to investigate calculation errors of nurses by means of a pencil and paper test found that 1 dosage in 12 was incorrect by a factor of more than 10 (Perlstein et al., 1979). Another study (Barker and McConnell, 1962) found, by ward observation, that an average nurse makes a dosage error once for every six administrations ordered. The best nurse observed had an error rate of 1 in 13. Both of these studies also showed that the nurses had no idea that they were making the errors and that they demonstrated considerable misplaced confidence in the accuracy of their calculated dosages.

The Perlstein study does not give a true indication of the error rate in calculations, since the questions asked were difficult or unusual examples, so the error rate in practice would probably be much less. On the other hand, the ward observation study is somewhat alarming since it reports the errors which actually did occur. No doubt, many of the observed errors were due to factors other than incorrect calculation, but th se errors are no less serious and their causes must be identified. This study is an attempt to investigate some of these additional souces of error, in the Papua New Guinean context, as well as the abilities of the student nurses at drug calculations.

1.5 THE NECESSITY FOR THE CALCULATIONS

Many doctors recommend that all prescriptions be given in a form which requires no calculation. They have observed many errors in the administration of doses, and the suggestion is that many of the errors can be avoided by prescribing the drug as the number of mL to be administered or in tablets as the case may be. There are two books which are used as references; the "Blue Book", (PNG Paediatric Society, 1980) and the "Green Book", (PNG Health Department, 1980). These publications are designed to be used by health personnel, from aid post orderlies to specialist paediatricians. By referring to the appropriate section, the treatment and amount of medication can be directly read. The books are widely used and they are given widespread support from doctors and nurses alike.

Nevertheless, the books do not circumvent the need for nurses to be able to perform dosage calculations. Some of the reasons for this are as follows:

a) Even in the hospitals where the books are widely used, there are many prescriptions ordered in mg. The doctors in Wewak hospital, for example, said that all drugs are prescribed in mL or tablets, but on studying the patients' charts it was found that no fewer that 10% of all prescriptions were in mg;

b) Certain drugs are dependent on other factors. For example, the dosage of insulin is dependent on the

sugar content of the urine. This is measured by the comparison of a test card against a colour chart, which indicates the dosage in units. From this the number of mL of solution must be determined, so the nurse is required to perform the calculation;

c) The method of dilution of vials affects the concentration of the solution. Procaine Penicillin requires 10mL of sterile water to be added, yet some hospitals report that they add only 7mL. This is of no concern if the drug is prescribed by mass of active ingredient or number of units, but if prescribed in mL of solution, then the dosage will be different to that which is intended;

d) The available form and strength of medication is not always as indicated in the book, and the doctor may not be aware of the variation, so there is a danger that the incorrect strength may be prescribed.

Further, in order to be a fully integrated part of the health care professional team, it is necessary for nurses to understand as far as possible all aspects of the drug delivery process. It is not possible for the nurse to check on the appropriateness of a prescription unless she/he knows the solution strength and can perform the necessary calculation.

This is not an argument against the use of the standard treatment books. It appears that the process of drug delivery

has been made more efficient and that there are fewer errors since the introduction of the books. However it does indicate that there is still a need for nurses to be competent at the calculations whenever they are necessary. It also means that the schools of nursing must continue to ensure that their graduates are both competent and confident at all aspects of drug calculations.

2. THE STUDY

2.1 AIMS

The study aimed

(i) to test the abilities of student nurses at the calculation of drug dosages by a pen and paper test,

(ii) to test the abilities of student nurses in the practical administration of drug dosages,

(iii) to determine the extent of the relationship between the two tests,

(iv) to investigate the extent and type of student errors in the tests.

2.2 STRUCTURE

THE WRITTEN TEST

The written test was administered on a group basis. The test consisted of the following six items.

DRUG CALCULATIONS

NAME: _____ SCHOOL: _____ YEAR: _____ DATE: _____

SHOW ALL YOUR WORKING

1. Chloroquine is available as 80 mg in 2 ml. 50 mg is prescribed for a patient. How much solution must be given?

2. Pethedine is available as 100 mg in 2 ml; 80 mg is prescribed. How much solution should be given?

3. Streptomycin comes in a vial containing 5 g in powder form. If you add 7 ml of sterile water, you get 5 g in 10 ml of solution. How much should be drawn up if 750 mg is ordered?

4. Procaine Penicillin comes in a vial which contains 3 000 000 units of drug. If you add 10 ml of sterile water, you get 13 ml of solution. How much solution should be drawn up for 750 000 units?

5. 0.25 mg of Digoxin is prescribed. Digoxin is available as 50 mcg in 1 ml of solution. How much solution should be given?

6. 100 mg Aminophylline I.V. is prescribed. It is available as 250 mg in 10 ml of solution. How much solution should be given?

Items 1, 2 and 6 require a direct calculation of the dose. Item 3 involves a dilution, and also a conversion from g to mg as well as the calculation. Item 4 also involves a dilution, and a comparison of the number of units required. Item 5 requires the conversion from mg to microgram (mcg) prior to the calculation.

THE PRACTICAL TEST

In the practical test, the same questions were posed in a simulated ward situation. The students were tested individually.

Each prescription was written on a drug sheet obtained from the hospital as shown in figure 3.

DM WAFI AGE 30 SEX M WEIGHT (Kg) 60 KG

	IMI CHLOROQUINE 50mg DAILY x 3/7	IMI PETHEDINE 80 mg 6/24 PRN	IMI STREPTOMYCIN 750 mg DAILY x 2/52	INI P/PENICILLIN (AMOCILLIN) 750,000 4/4 DAILY x 7/7	O DIGOXIN 0.25mg 8/10 PRN	IVI AMINOPHYLLINE 100 mg DAILY PRN

Figure 3. Prescription sheet

A "drug trolley" was set up with a selection of drugs, including each of the drugs ordered above. A range of syringes, needles, cotton wool, medicine glasses, paper, pens, standard treatment books, and a card indicating standard dilutions were provided. To perform each task correctly, the student would have to:

a) Read the prescription

b) Select the correct drug and determine its concentration

c) Calculate the dose

d) Select the appropriate syringe

e) Draw up the correct amount

Figure 4. Naomi Benjamin conducting an interview with a second year student.

Ideally, the practical aspects of drug administration would have been observed in the wards. It was not feasible to do this. In the wards, it would take many hours of observation of each student to ensure that the various drugs were identified. To cover the entire group would take a number of weeks. In any case, the presence of an observer on the drug rounds would create an artificial situation and the advantage of the natural observation would be lost. By conducting the test individually in a simulated ward situation, it was possible to cover all of the students, and all of the precription types, in a reasonable period of time. This meant that the observer would not have to rectify the errors as soon as they occurred, as would be the case

if there were a real patient involved. The student could be allowed to continue to the conclusion. It also meant that the students could be interviewed about their errors to gain additional insights into the causes; this would not have been practical in the wards.

2.3 SUBJECTS

The second and third year students from the Wewak School of Nursing were tested. The 14 second year students were in a lecture block at the time and all did both tests. The third year students were involved in hospital duties, and it was not possible to locate them easily. Nineteen students did the written test, eighteen did the practical test, with sixteen of them completing both. Included in the third year sample were 7 students who had recently transferred from Goroka, but there is no reason to separate them for this study.

2.4 PROCEDURE

The written test was administered to both groups together. After the students had completed the test, an explanation was given of the practical test and the purpose of the tests.

The practical test was administered individually, so that each student could be observed in detail. A standard procedure was used for each individual. After an initial greeting, the students were asked their name, year of studies and home province. The directions for the test were explained. The observer then indicated the first prescription and the students

were asked to show how they would administer the ordered drug. The various steps in this procedure were recorded on individual observation schedules designed for this purpose. (Appendices 1 and 2 contain the protocol sheet used and a sample student record). The students were allowed to proceed with the calculation until the dose was prepared. If the students stopped and could not continue, they were questioned to determine whether it was due to lack of knowledge or failure to understand the testing procedure. In the former case, no advice was given; in the latter, the students were given the general instructions again. If the final answer was incorrect, the students were asked the following questions

"Read the prescription"

"What does it mean?"

"What is the next step?" etc.

"Is that your answer?"

"Would you administer that dose?"

If the students omitted information of specific interest, they were asked a more direct question. The aim of the clinical interview was to determine the basis of any errors, so if it was necessary to vary the questions to ascertain the source of an error, this was done. The observer then repeated the procedure with the second and subsequent prescriptions.

A research assistant from the Mathematics Education Centre, Naomi Benjamin, was available to complete a second observation schedule to validate the records of the interviews. For the

first afternoon, each observer completed a separate record and these were compared after each interview. Two things were clear at this stage. Firstly, after the second interview there was considerable agreement on the observations and the records. Secondly, the interviews were taking very much longer than had been anticipated. At this stage, the test was divided into two halves, with each observer covering three prescriptions for each student. This was necessary to ensure that the testing was completed in the time available, with enough time given to each student so that the sources of error could be identified. At the start of each session, the observers combined for one student as a further check that the records were reliable. The level of agreement remained high and so there was no loss af accuracy in dividing the test in this way. Sr. Jenny Cameron from the Wewak School of Nursing also observed a number of the later interviews, providing an additional check on the reliability of the observations.

3 RESULTS

3.1 THE WRITTEN TEST

The results on the written test are given in Table 1. There were 6 questions on the test.

	2nd. Year n=14	3rd. Year n=19	Total n=33
Mean	5.57	4.84	5.00
S.D.	1.34	2.40	0.90

Table 1. Results on the written test.

The facilities for each question are shown in Table 2 as percentages.

Question No.	2nd. Year	3rd. Year	Total
1. Chloroquine	93	95	94
2. Pethedine	100	100	100
3. Streptomycin	93	89	91
4. Procillin	86	53	67
5. Digoxin	86	42	61
6. Aminophylline	100	79	88

Table 2. Facilities of written test questions.

The second year students scored significantly better than the third years' (t-test for independent samples, s.d. different, t= 7.63, significant >>0.001). It is not clear why this should be so, although one possible explanation is that by all reports the selection of the intake in 1981 was more thorough than previously. The second year students scored very well indeed on the written calculations and there need be no concern at all about their ability at these tasks. The third year students did not perform as well, and considering that they have only one further revision block before their examinations, their results were a little disappointing. They were able to do the more straight forward tasks but a number of students exhibited specific weaknesses on the more difficult questions. Table 3 gives a breakdown of the particular errors which the students made on the calculations.

ERROR	2nd. Year	3rd. Year
Incomplete formula		1
Cancelling		3
Multiplication		4
Division	2	2
Dilution	2	6
Unit conversion	2	11

Table 3. Incidence of particular errors.

Only 12 out of the 33 errors occurred in the calculation itself. Thirteen errors were due to an incorrect unit change; all on the conversion from mg to mcg. Eight errors were due to the use of incorrect dilution factors, which was a little surprising since the information was provided in the question. There were few errors which were due to incorrect application of the rule or inaccurate arithmetic.

3.2 THE PRACTICAL TEST

The purpose of this aspect of the study was to compare and contrast the students' performance on the written and practical tests. The patterns which emerged in both the second and third year groups are very similar and so the results are combined for simplicity.

Table 4 presents a comparison between the scores on the written and practical tests.

	WRITTEN TEST	PRACTICAL TEST
Mean	5.0	3.78
S.D.	0.90	1.62
	r=0.73, significant > .01	

Table 4. Comparision between practical and written test scores.

The practical test scores are considerably lower than the written test scores, but there is a highly significant correlation between the scores. Thus although the students made more errors in the practical situation, it seems the simpler, administered written test should be able to predict this. Table 5 gives a breakdown of the types of errors and their frequencies.

TYPE OF ERROR	FREQUENCY OF ERRORS	PERCENTAGE OF TOTAL RESPONSES
Reading the prescription	2	1.1
Arithmetic calculation	12	6.7
Unit conversions	13	7.2
Incorrect dilution	25	13.9
Incorrect concentration	7	3.9
Reading the scale on the instrument	13	7.2
TOTAL	72	40

TABLE. 5 Practical test errors.

The most frequently occurring error was the use of an

incorrect dilution factor. In the practical test this error could occur in two questions. The standard treatment book requires that 7 mL of sterile water be added to Streptomycin to make 10 mL of solution. Similarly, 10 mL of sterile water must be added to Procaine Penicillin to make 13 mL of solution. In the written test, this information was provided (although some students disregarded it). In the practical test, the student either had to remember this fact or read the book or chart provided for this purpose. All of these 25 errors resulted from the students incorrectly remembering the dilutions. All were confident of their responses and all of the dilutions given were reasonable. Most did not realise that it was possible to check such information, and none made any attempt to do so. Most of the students would regularly be administering such drugs in the hospitals; it is not clear how they performed the dilutions there.

There were 13 cases where students correctly calculated the answer but drew up a different amount in the syringe. This error was only recorded if the drawn amount deviated by more than 10% from the correct reading. None of the errors were particularly serious, yet there are certain drugs, especially in paediatrics where accuracy is important.

Table 6 presents a comparison between the errors on the written and practical tests. Since the errors due to incorrect dilution factors and the use of the incorrect concentration are similar, they are grouped together in this table. Both types of

error arise if the student fails to check the specifications of the drug. The frequency of each error type is given and the bracketed figure expresses the error frequency as a percentage of the total responses.

ERROR TYPE	WRITTEN TEST	PRACTICAL TEST
Calculation	12 (6%)	12 (6%)
Dilution Factor	8 (4%)	32 (17%)
Unit conversion	13 (7%)	13 (7%)
Reading	0	2 (1%)
Scale reading	0	13 (13%)
TOTAL	33 (17%)	72 (38%)

Table 6. Comparison of error types.

The incidence of calculation errors is similar on both tests, although there was only one case where a student made the same error twice. This suggests that the calculation errors are due to carelessness, and are not stable misconceptions. The errors due to incorrect conversion of units occur at the same rate in each test. There were seven cases where students made the same mistake in each test. Those students probably do not understand the necessary conversions.

There are four times as many errors on the practical test that are due to the use of the incorrect concentration or dilution. While the written test provided the necessary information, on the practical test the students were required to determine the information from the available sources. The written test creates an artificial situation on this point and

this very real source of student errors in the administration of drugs is not apparent. The same can be said about scale reading. There is clearly potential for error in the measurement of the dose, yet a written test will not reveal the extent or the types of such errors.

The written test yields reasonably reliable information about the abilities of the students at the calculations and converting units. It does not provide any information as to whether the students can determine the key information about the drugs, nor whether they can accuractly measure the doses. Since there is a high correlation between the test scores, a written test possibly can distinguish between the strong and the weak students at drug administration, but it does not provide reliable information about the extent and types of errors that they might make in the practical situation.

3.3 OTHER OBSERVATIONS

No student would have administered any over-large doses. There were a number of occasions when an answer like 15mL was reached. Those students immediately recognised that this was wrong and in most cases recalculated the answer. If the correct answer was given without prompting, they were considered as correctly completing the item. It appeared that the students have a reasonable idea of the appropriate size of these doses.

The manipulation of equipment was also very good, and no student appeared to experience any difficulty with any of the

procedures.

On three occasions, a "buggy" procedure was noticed. The students converted 0.25 mg to 2500 mcg, then after completing the calculation found the result was 50 mL. This was too large, they said, so they gave the answer 5.0 mL which they proceeded to draw up. Their answer is correct but they were not awarded the point. It may be that the students have frequently done this in class. Since this incorrect unit conversion only requires some fiddling with the decimal point to get a reasonable dose, they would often arrive at the correct answer. This would then reinforce the method for those students. It is potentially dangerous. There are some medications which require doses in excess of 10 mL, and these students may arbitrarily reduce the dose by a factor of 10. It does highlight the necessity for tutors (and in fact, all teachers) to try to observe their students closely to identify if possible any errors which are being consistently applied.

4 DISCUSSION

The overall aim of this component of the nurse training course is that the students will be competent and confident at all aspects of drug administration. It has been obvious to personnel involved in nursing education that for some time, the students have been experiencing difficulty with drug calculations. The Papua New Guinea Nursing Council sets an examination with an 80% pass mark for final year students. Failure to pass debars the student from graduation. At one time the schools required the nurses to work through a self paced

course of basic arithmetic. This has been replaced with a program specifically directed to the nursing calculations, which is now formally timetabled in many schools. Since the drug calculation examination is so important for the students, the schools must devote considerable energy towards teaching the pen and paper aspects of drug calculations. It is generally true that if an examination is considered important, then the examination itself determines not only the content and emphasis of the course, but the way in which the course is taught. The nett result, in this case, has been that the students are now quite proficient at the calculation of drug dosages. It has not meant that the students are necessarily able to accurately administer the required dosages and it may be that the very important practical aspects of the process are being overlooked.

This study indicates that there are important aspects to the administration of drug dosages other than the calculation. In particular, students experienced difficulty in reading the scales on the syringes, and there were many errors made in determining the concentration of the available drug and, when necessary, the procedure for dilution of the drug.

More emphasis should be given in the teaching program to the accurate reading of measurement instruments, especially syringes. This can best be done with the actual instruments used in the wards. The work of the students should be closely monitored so that errors can be identified and the appropriate remediation advice given.

The students should also be taught not to rely on their memory for information about drugs. The amount of active drug and the amount of solution should be checked in each case. Where a dilution is necessary, the students should check either the appropriate table or a standard treatment book to determine the amount of sterile water to be added and the amount of solution which is produced.

Once the various components of the task have been taught, the process should be treated as one procedure. There should be time made available for teaching the entire process and if possible, the students should be tested on the whole procedure in a practical way. Ideally this could be done by clinical supervisors, but in their absence, the responsibily will rest on the tutors. If the calculations are to be tested, it will be necessary to test the whole procedure as well, otherwise the students will consider the calculation to be the only important component of the administration of drugs.

More generally, it suggests that there is a very real need to integrate all technical mathematics teaching with the trade applications. As has been pointed out many times, basic arithmetic is not the major problem (see for example, Sullivan,1981; Ros,1982). The difficulties are experienced in the application of the arithmetic to practical situations. But further than this, the application of the arithmetic is only one step in an overall procedure. Any technical mathematics course should be supplemented with integrated practical activities which

simulate as closely as possible the real application of the mathematics.

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APPENDIX 1

PROTOCOL SHEET

Room to be set up with drug trolley including drugs, medicine glasses. 5 prescriptions written on a standard sheet. Individual interview, purpose of study previously explained. Paper and pencil available, but not provided. When student enters

1. Initial greeting
2. What is your name please?
3. What year are you in?
4. Where in your home province?
5. We are intersted in seeing how you administer drug doses
6. Imagine that this prescription (point to lst one) is ordered. Show me how you would administer this amount of drug.

   (a) Identify lst error

   (b) Identify future errors

   (c) Prompts given (and recorded) when student is unsure of the next step

   (d) "are you confident of your answer?"

7. After completion

   (a) "Please read the prescription"

   (b) "Explain your steps in the calculation"

   (c) Other specific questions or any other errors

8. Score of 1 point if end result is correct.
9. Go back to 6.
10. Thanks etc.

APPENDIX 2 WEWAK SON.

NAME YEAR HOME PROVINCE AUGUST, 1982

	DRUG 1	DRUG 2	DRUG 3	DRUG 4	DRUG 5
READ THE PRESCRIPTION		Amount Drug Route Time		Amount Drug Route Time	
CALCULATE THE DOSE		Formula Check drug Strength Substitute currectly Multiply correctly Present answer		Formula Check drug Strength Substitute correctly Multiply correctly Present answer	
SELECT THE DRUG		Yes No		Yes No	
CHOOSE THE APPARATUS		Best Suitable Not Suitable		Best Suitable Not Suitable	
DRAW UP THE CORRECT AMOUNT		Yes (within meniscus) within 10% outside 10% confident		Yes (within (meniscus) within 10% outside 10% confident	

COMMENTS: .....

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